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East Europe Report

SCIENCE AND TECHNOLOGY

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18 March 1985

EAST EUROPE REPORT

SCIENCE AND TECHNOLOGY

CONTENTS

GERMAN DEMOCRATIC REPUBLIC

BRIEFS

NEW PHYSICS INSTITUTE DIRECTOR--Prof Dr Volker Schmidt was yesterday installed in a solemn ceremony as the new director of the GDR Academy of Sciences' Institute for Solid State Physics and Electromicroscopy in Halle. Until now, he had been head of this internationally renowned research center's plasticity and fracture research department. In a laudatory address, academy president Prof Dr Werner Scheler outlined the accomplishments of the parting director Prof Dr Bethge. [Text] [Dresden SAECHSISCHE ZEITUNG in German 5-6 Jan 85 p 2] 7994

NEW CYBERNETICS, AUTOMATION DIVISION--The GDR Academy of Sciences established on Thursday a division for informatics, cybernetics and automation. Under the direction of Prof Dr Ulrich Hofmann, the members and guests of this new course of study will discuss fundamental scientific and scientific-political problems of this research area which is so important to our economy and the development of our society. Based on the most recent scientific findings and development trends and starting from the needs of our society, they are going to work out positions and recommendations for coordinating and directing the individual disciplines of this complex scientific field. [Text] [East Berlin NEUES DEUTSCHLAND in German 15-16 Dec 84 p 12] 7994

GLASS CERAMIC FOR PROSTHESES--A biocompatible glass ceramic material to replace bones has been developed by the Friedrich Schiller University's chemistry department in Jena. As Prof Dr Werner Vogel, director of the glass chemistry section and the Otto Schott Institute of the Jean university, explained in SOZIALISTISCHE UNIVERSITAET (No 6/84), this new glass ceramic material can be turned, milled, drilled or threated with ordinary carbide tools without using diamond tools. The new material is reported to contain mica and apatite crystals. Numerous tests on animals reportedly have shown that the body's bone tissue does not reject the implanted material as a foreign substance. The glass ceramic can be shaped and used in a way that makes it possible to obtain a strong bonding with the bone. [Text] [East Berlin NEUES DEUTSCHLAND in German 15-16 Dec 84 p 12] 7994

CUTTING MATERIAL IMPORTS INCREASE--In 1985, the GDR plans to import to a larger extent superhard cutting materials from the USSR. This is the information the director of the machine tool department at the Research

Center of the Tool Industry, Dr Stefan Becker, provided. This is in response to the increasing need of several hundred industrial firms and research institutions in the GDR who require synthetic diamonds and hard boron nitrides for shaping with cutting tools. [Text] [East Berlin BERLINER ZEITUNG in German 29030 29-30 Dec 84 p 2] 7994

EISENHUETTEN STEEL ROLLING COMBINE--The construction of the converter steel mill of the Eisenhuetten Combine (East) is so-to-speak the central part of putting into effect the decision on developing the GDR refining metallurgy. It is above all a question of improved material savings, increased productivity and better quality of products. The modern process makes it possible to improve working and living conditions, to make extensive use of waste products and to cut transportation costs. Its great economic significance is shown, among other things, by the fact that 13 percent less material is needed to produce the same quantity of steel than in the Siemens-Martin process. The consumption of energy per ton of semi-finished products is reduced by 28 percent. The reason is that the liquid pig iron from the blast furnaces is directly processed by the converter into steel without solidifying and is then made into metallurgical semi-finished products by continuous casting. This means that several production stages, which are currently used at GDR steel and rolling mills, can be eliminated, i.e., processes that were always associated with loss of materials such as waste of rolling material and the use of more energy. The converter itself consists of a tank lined with fireproof material. It contains the still-liquid pig iron from the blast furnace and scrap metal (up to 25 percent). Pure oxygen is then blown into the pig iron and during that process, such impurities as carbon, silicon, manganese, sulfur and phosphorus are oxydizing. The heat that develops during the oxydization keeps the melt liquid and causes the scrap to melt as well. No additional energy is necessary. Unlike the converter steel mill, the open-hearth steel mills in Brandenburg and Hennigsdorf work with solid materials in the form of pigs from the furnace and with scrap metal as secondary raw material. The open-hearth process, on the other hand, meets an important economic objective because it uses mostly domestic raw materials (up to 75 percent scrap metal). It permits the variation of their composition in line with existing economic conditions. For that reason, a considerable proportion of pig iron will continue to be produced via the open-hearth process in the years to come. [By Karl-Heinz Albrecht, steel and rolling mill Brandenburg] [Text] [East Berlin TRIBUENE in German 13 Dec 84 p 5] 7994

BALL BEARING PRODUCTION IMPROVEMENTS--A new generation of balls is being produced by the ball bearing plant in Schweina, which, combined into ball bearings, will permit many industries to improve the quality of their finished products. The balls, which have diameters between 1.5 and 31.9 millimeters, deviate in their surface rounding, in part, by only .13 micrometers from the so-called ideal circle. In comparison, hair on human heads is, on the average, almost 1,000 times thicker. [In the photo--not reproduced] Rosemarie Keybe is measuring the high-precision balls with a 20,000-fold magnification under a Universal Roundness Measuring Instrument. [Text] [Magdeburg VOLKSSTIMME in German 15 Oct 84 p 3] 7994

COPPER CONTENT MEASURING DEVICE--A newly developed measuring device enables specialists in the light metal construction combine's Plauen plant to determine the copper content of a dipping pan within minutes. This precedes the galvanization of steel parts. In copper plating, a .2-.5 micrometer metal layer is applied. Subsequently, the extremely thin copper layer facilitates a better flow of zinc when it is taken out of the dipping solution. This way, up to 7 percent of zinc can be saved. Very low tolerances are required for the copper layer. This makes it necessary to constantly maintain an optimal concentration of copper in the dipping pan. In the past, it was only possible to determine the proportion of copper in a laboratory. One of the disadvantages was the big time lag between the time the sample was taken out and the results became available, because the metal concentration changes continuously during the production process. [Text] [East Berlin NATIONALZEITUNG in German 5 Dec 84 p 5] 7994

MOLECULAR-BEAM EPITAXY DEVICE--The production of single-crystal layers of semiconductors is being studied by graduate crystallographer Dr Rudolf Hey and the physical-technical assistant Karin Haupt on a molecular-beam epitaxy device. The instrument was manufactured at the Central Institute for Electron Physics. Molecular-beam epitaxy (MBE) is a new technological process which generates from separately produced, directed particle streams of atoms and molecules epitaxy layers on semiconductor crystals with predetermined composition and sharp doping profiles. [Text] [East Berlin NEUES DEUTSCHLAND In German 5-6 Jan 85 p 12] 7994

CSO: 2302/55

HUNGARY

BRIEFS

ACADEMY COMPUTER, DATA BASE SERVICES--The computer service of the library of the Hungarian Academy of Sciences subscribes to the Weekly Literature Alerting Service of ASCA operated by the Institute for Scientific Information, located in Philadelphia. The information provided serves basic research in the field of natural sciences keeping track of such information as reported in the 3,500 most important natural science periodicals from a great variety of countries. Numerous Hungarian research institutes and industrial enterprises subscribe to this service of the academy library. The library also stores several 10 million data bases on magnetic tape. [Excerpt] [Budapest NEPSZABADSAG in Hungarian 5 Feb 85 p 6]

USSR SCIENTIFIC COOPERATION--Budapest, 14 Feb (MTI)--Under their workplan of cooperation signed in Moscow recently the Hungarian Academy of Sciences and the Soviet Academy of Sciences are to conduct joint research in 125 natural and 30 social scientific themes in the next five years. The cooperation programme includes, among other things, research into special crystals and elaboration of their production technology, development of quantum electronics and of equipment for processing optical information. Hungarian and Soviet scientists will study the use of new physical phenomena in microelectronics and search for solutions to increase the speed of operation of magnetic memories. The Hungarian Central Physical Research Institute will continue its participation in the Soviet space research programme. Hungarian and Soviet scholars will study the social and political development of socialism and exchange views on the situation and problems of the youth. They will jointly elaborate the practical method of public opinion sounding and a comparative study of the historic and cultural inheritence of the Soviet and Hungarian peoples is also planned. [Text] [Budapest MTI in English 1033 GMT 14 Feb 85 LD]

CSO: 2020/69

POLAND

CURRENT STATUS, GROWTH GOALS OF MICROELECTRONICS INDUSTRY

Warsaw ELEKTRONIKA in Polish No 6, 1984 pp 4-7

[Article by Prof Cezary Andrzej Ambroziak of the CEMI Institute of Electronic Technology in Warsaw: "The Present Status and Development Trends of Research in Poland's Microelectronics Industry"]

[Text] The present status and development trend of research in Poland's microelectronics industry is based primarily on two programs initiated in the 1970's.

The first program is the program to develop MOS [metal oxide semiconductor]/ LSI [large-scale integration] IC's [integrated circuits]. The second program, a natural development of the first program, is the program to develop IC's for microprocessing systems. Both programs are financed by central funds, often by the government's PR-3 scientific research program "The Development of Materials and Components for Electronics Applications," and by ministerial resources. The implementation of these programs became possible because of the vital investments initiated during the 1975-1980 period when the TEWA Semiconductor Factory Plants and the Institute of Electronic Technology were built within the framework of the CEMI Scientific Production Center for Electronics. This was a prerequisite for effectively surmounting our country's next microelectronics technology barrier and for mastering the production of a large assortment of new-generation LSI IC's. This was accomplished primarily by developing our own scientific research centers.

The development of the microelectronics industry can be examined in several aspects as follows:

1) the increase in assortment from the viewpoint of different areas of application;

2) the development and progress of various technologies;

3) the development of methods for designing IC's;

4) the development of methods for testing IC's.

Let us examine these four aspects of microelectronics development in Poland.

Policy in the area of increasing the assortment of IC's has changed significantly over the past 5 to 8 years. In previous years, when the command system existed in planning, much emphasis was placed on developing circuits for consumer goods produced within the Unitra Association framework.

This trend also exerted a strong influence on assortment selection during the first years of developing MOS LSI IC's. They consisted primarily of circuits for electronic watches and various types of calculators, and for remote control of TV's and the like. In general, there was a lack of resources to develop industrial IC's for automation, telecommunications, measuring and control apparatus, and the like. The stimulus to create a central program devoted exclusively to industrial IC's, primarily for microprocessors and memory circuits, was the rapid development of microelectronics technology during the 1970's.

The process of changing from consumer goods IC's to developing IC's for industrial equipment expanded significantly after the economic reform was implemented. Since that time, non-central plan orders began to be received by ITE and TEWA from individual firms to develop specific circuits for their needs. Many Polish enterprises rightly believed that very soon they would be unable to export either to the I or II payments area unless they quickly electronized their products. Undoubtedly, another reason for the need to develop new IC's in Poland is that foreign-exchange subsidies from the central government to many enterprises decreased significantly compared to previous years, and that it has become more difficult to purchase industrial components because of the tightened embargo. Thus, after the dramatic decrease in orders for Polish components in 1981, at times as much as 50 - 60 percent of 1979's orders, current demand for some assortments exceeds possible supplies several times over.

Table. Production of MOS IC's during the 1981-1983 period and projection for 1984

Produkcja układów MOS w latach 1981—83 oraz plan na r. 1984

	1981	1982	1983	1 1984 (plan)
2 Produkcja tys. szt.	397,6	432,0	1229,3	1515
3 Sprzedaż tys. szt.	364,2	415,0	1276,5	
4 w tym Eksport tys. szt.	41,5	75,6	20,8	
5 Liczba typów produkowanych układów	21	33	72	

Key:
1. 1984 (projected)
2. Production in thousands of units
3. Sales in thousands of units
4. Including exports in thousands of units
5. Number of IC types produced

ITE also received orders from foreign customers to develop new IC's. Contracts were signed with firms from three CEMA countries. One contract has already been filled, and two are in the process of being realized.

In addition to microprocessor and memory circuits, the following industrial IC's also have been or are being developed: CMOS logic circuits to replace TTL [transistor-transistor logic] bipolar circuits; telephone equipment circuits; digital voltmeter circuits; electronic power meters; and control programmes.

It is projected that IC's for radio, TV and audio equipment will be available again that will be based on the development of a new generation of LSI circuits that make extensive use of digital processing of signals.

The table illustrates the development, in assortment and number, over the past several years of the most advanced circuits in MOS technology.

The introduction of many new IC assortments depends to a great extent on mastering several supplementary technologies. Presently, we possess the following technologies:

--P-MOS technology is the oldest of the developed technologies and was used mainly to produce calculator chips and some other chips designed for line feeders. Presently, this technology is developed, but it is still being used in production.

--N-MOS technology is one of the basic technologies. It consists of several versions and continues to be developed. It was developed from the viewpoint of memory and microprocessor chips. Initially, it was developed as an aluminum gate and then as a silicon gate. While this technology was being developed, a whole series of new technological processes were developed and gradually implemented. Among other processes, there was the process of oxidation by synthesizing steam with hydrox-type liquid gases and the use of HCl, and the process of oxidation in dry oxygen and the use of HCl, which applies to gate oxides.

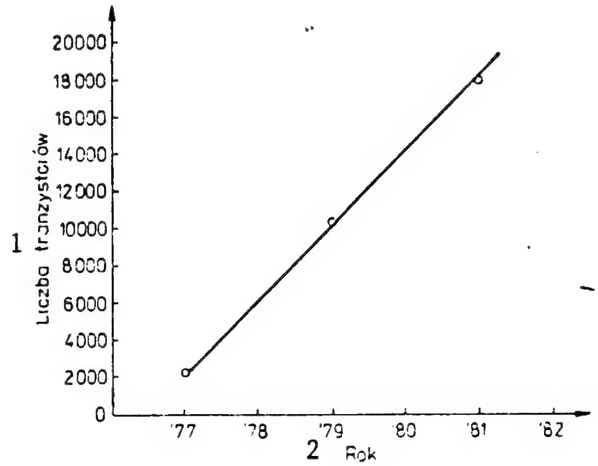

Figure 1. Increase in scale of integration for Polish IC's

Key:

1. Number of transistors
2. Year

In the intial years, the fabricated polysilicon gate wafers were used in epitaxy. Then the LPCVP low-pressure deposition method for fabricating doped polysilicon wafers was also developed. Methods for fabricating Si_3N_4 nitrogen wafers and ways to etch them were also developed. In the initial years, wet etching chemicals were used, but the significantly better plasma etching methods were developed and implemented for microprocessor circuits. Mastering the fabrication and plasma etching of Si_3N_4 wafers enabled the implementation of the LOCOS type dielectric isolation in most large N-MOS technology microprocessor circuits.

In N-MOS technology using a silicon gate, a series of 8080A microprocessor circuits as well as 16K ROM (read only memory) and 4K RAM (random access memory) memories, among others, were developed using a silicon gate.

--CMOS technology. Several variations of this technology have been developed and implemented. Among other things, they differ in the maximum voltage applied, from the low-voltage clock circuits powered by a single battery to high-voltage logic circuits.

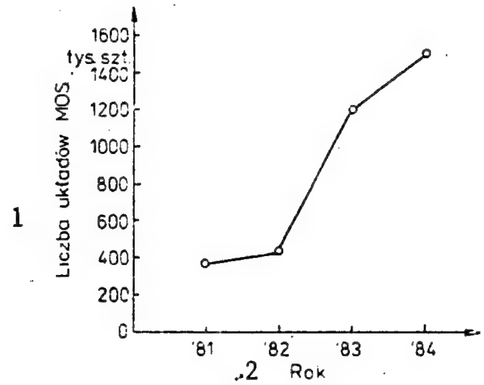

Figure 2. Increase in production of MOS IC's in Poland

Key:

1. Number of MOS IC's
2. Year

In clock circuits, this technology enabled maximum transistor voltages on the order of 1 V to be controlled with an accuracy of +/- 0.05 V. This is achieved primarily because of the excellent ion implantation control.

The next stage in the development of CMOS technology will be the development of silicon gate CMOS circuits.

--TTLS technology. The requirements of microprocessor systems led to the development and significant improvement of the technology of bipolar circuits with Schottky diodes. The developed technology is useful for LSI IC's with aluminum Shottky contracts that satisfy extreme climatic requirements.

In TTLS technology, an original method of isolation via two-sided diffusion of implanted wafers is being used. Implantation using a high current beam is being applied.

Photolithography processes are used in all of the above-mentioned technologies, which enables dimensions as small as 3.5 μm to be achieved. Emulsion and chrome masks and negative and positive emulsions are used depending on requirements. Automatic centering and irradiation have been developed for some circuits.

Undoubtedly, additional research work will be conducted to improve photolithography resolution to 2 μm. This requires the use of electron lithography to create masks and the use of a new generation of centering and irrdiation equipment.

The development of new technological processes and combining them in useful sequences to permit the fabrication of LSI IC's goes hand in hand with the development of methods to investigate the properties of fabricated and modified wafers of the various materials appearing in IC's.

The ITE has developed and is using a computer-based engineering diagnostics system. It is projected that over the next several years a computer-based system to diagnose and control production will be installed in the factory.

Computer systems to simulate technological processes have been installed at the ITE, which permit the number of expensive engineering to be reduced.

In summary, it can be said that in the last 2 years we have acquired some of the most modern technologies for LSI IC's among the CEMA countries. The reason for this, among others, was the contracts from two firms from two countries for ITE to develop the technology for the masks for circuits designed in these countries. These projects were the basis for exporting technology. However, as a result of decreased investment in electronics in Poland while this investment was being increased in other CEMA countries, the difference in levels of technology is beginning to equalize.

In discussing new technologies, one should keep in mind the inseparable link between technological capabilities and available equipment. Up to that time, most technical equipment was imported from payments area I or II. However, in the past few years, proven domestically produced equipment have become available in Poland, including a microprocessor-controlled difussion ovens produced by the Industrial Institute for Electronics, the modifications of plasma etching equipment by the Wroclaw Polytechnic ITE, and many others. This process of developing technical equipment in Poland should be expanded. A number of agreements to develop new technical and research apparatus are now included within the framework of the PR3 government program. The scientific research institutions involved with developing equipment have an important role to play here.

No less difficult than the technological barrier is the barrier associated with designing and manufacturing masks for LSI and VLSI (very large-scale integrated) IC's. In Poland this technology was mastered in an area that enabled the development and production of MOS LSI IC's containing up to 17,000 transistors. This requires the precise placement of several hundred thousand elementary figures on the masks in seven to nine layers. If one of these several hundred thousand rectangles is missing (for example, a connection to one transistor) then the entire system is unreliable. Designing such circuits can be executed efficiently only with use of a computer.

An interactive CAD [computer aided design] system has been in use and is being improved at the CEMI ITE for several years now. We have developed many of our own control and testing programs. A system based on Polish and other CEMA country equipment is also being developed. Software for designing IC's is also being developed by several schools in Poland. However, it can be stated that Polish institutions involved with industrial computer resources that are supposed to be concerned with the development of software and hardware to design LSI and VISI IC's in general did not pay sufficient attention to this problem. Work in this area should be expanded and coordinated on a national scale because in the area of CAD interactive design, initially developed to design electronic circuits, is being used extensively all over the world in many other industries, from the shaping of metallurgical castings to the

building of airplanes and ships. Limiting oneself to drafting boards is now an anachronism.

Computer testing of LSI IC's at the silicon wafer stage as well as at the finished product stage is an area that is linked with technology and design. To establish with a high degree of certainty that a complex system, such as an LSI IC, a calculator, or 4K memory chip, is good, millions of tests must be performed on it in a reasonably short time. Therefore, testing LSI IC's is a problem that is especially indebted to engineering inventiveness and ingenuity. For example, the first calculators in Poland were tested in accordance with an algorithm which required 27 seconds per circuit. It is easy to calculate that with the production of several hundred thousand circuits, testing can become a bottleneck. As a result of improvements, the test was finally shortened to several seconds. However, simplifying the algorithm excessively will result in the acceptance of circuits that operate improperly, at times under very specific operating conditions. An interesting example is the calculator that we were able to bring to production that would not multiply twos, and only twos. This was discovered by chance by one of the users of the computer, which led to the discovery of an error in the logic circuit. Similar cases are known to have occurred in the operations of many world renown firms.

To date, the problem of a compromise between a complete test of large memories and testing time and cost has not been resolved anywhere in the world. It is a fact that existing testing algorithims do not verify all possible operating states for large memories. Thus, sometimes the improper operation of a circuit is confirmed only when used by a specific user. The problems of generating testing algorithims are among the basic barriers in developing LSI IC's, and are resolved at the same time the circuit is being designed.

It should be emphasized with pleasure that many interesting programs to test complicated LSI IC's have been developed in Poland. A number of interesting testers also have been developed, especially by the Industrial Institute for Technical Equipment. As one of the areas determining the increased scale of integration, Poland should continue to develop this area intensively.

In as much as it is impossible to discuss the above problems in detail in such limited space, we are including an extensive list of the latest publications that reflect the present status of this area in Poland.

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11899
CSO: 2602/15

POLAND

PHOSPHORIC SALTS PRODUCTION CAPACITIES, PROCESSES SURVEYED

Gliwice CHEMIK in Polish No 11, Nov 84 pp 311-313

[Article by Dr Zygmunt Kowalski, Alwernia Chemical Plant: "Production of Phosphoric Salts From Thermic Phosphoric Acid"]

[Excerpts] The Alwernia Chemical Plant is Poland's sole manufacturer of thermic phosphoric acid. Its production was launched in 1963 on the basis of domestic technology, subsequently expanded and modernized. Two additional installations were established in 1971 and 1976. Currently, their total productive capacity on two lines is 62,000 tons of H3P04, which places Poland among ranking European products of phosphoric acid. Poland's production in its totality is based on the phosphorus supplied by the Soviet Union.

According to data listed in (1) [reference not given] the world's 1978 output of phosphorus, excluding the Soviet Union's, was 720,000 tons, of which nearly 80 percent was processed into H3P04, while the Soviet Union made 340,000 tons f phosphorus and processed 87 percent of this quantity into H3P04. These data indicate that, including the Soviet Union, the world production of thermic phosphoric acid was approximately 2.8 million in 1978, whereas the world's production capacities were 1.25 million tons of phosphorus (including the Soviet Union) and 4.1 million tons of H3P04.

The United States is the world's top producer of phosphorus and H3P04. In 1982, it manufactured 977,000 tons of H3P04, while utilizing only 50 percent of its 1978 productive capacity of 1.91 million tons of H3P04. The Soviet output of H3P04 was nearly 700,000 tons of P205 (966,000 tons of H3P04).

A giant among the Western European producers is the Hoechst company, capable of making nearly 500,000 tons of P205 (690,000 tons of H3P04) on its installations at Knapsack and Wlissingen, Holland.

Phosphoric Salts Production in Poland

Initially, phosphoric salts were made in Poland from extractive phosphoric acid. In 1967 installations for sodium tripolyphosphate with 35,000 tons annual capacity, and in the early 1970's an installation for phosphoric salt production under the method presented in Figure 1 [not reproduced],

were made operational in the Widzew chemical plant. The latter is used to make mono-, bi-, and trisodium orthophosphorite and acid sodium pyrophosphorite.

Interest in the production possibilities for phosphoric salts was generated by the availability of thermic phosphoric acid (ranging from the technical through the analytical reagent grade) at Alwernia. Steps were taken which resulted in the startup of production of TPFS (tripolysodium phosphorite), Figure 3 [not reproduced], in an installation with a 40,000-ton annual capacity, which helped curtail the imports of this product and, in effect, resulted in the elimination of the powder detergent problem from Poland.

While the TPFS installation was being designed, possibilities of using the same plant to manufacture other phosphoric salts were also considered, and appropriate design decisions were made. The production of acid and neutral sodium pyrophosphorite, both manufactured during intervals in the TPFS processing, began on schedule in 1983.

A block diagram of TPFS and phosphoric salt production emphasizing the most essential differences in process characteristics is presented in Figure 4 [not reproduced]. All of the salts are made by the calcination-pulverization method, Figure 2 [not reproduced], the differences centering on the selection of molar ratios Na2O:P2O5 (known as TM) for the neutralization process, and appropriate drying and calcination temperatures for each salt. While the processing of Na2H2P2O7 presented no particular problems (as noted in Figure 4, the primary characteristics of this process are not markedly different from the TPFS process), the Na2H2P2O7 process was considerably more difficult to master. In this case, process characteristics are substantially different from the TPFS process. The processing of a multi-phosphorite mix (composed 90 percent of sodium potassium-polyphosphorite Na4KP3O10) for the meat industry is anticipated to begin in 1984.

Because of their use in the food processing industry, all of these salts must meet very high quality requirements, which is why the "nonarsenic" variety of thermic phosphoric acid and grade S or grade I electrolytic soda are used in their production.

Alwernia's now routine processing of pyro- and polyphosphorites offers prospects for the production of orthophosphorites by the pulverization method as well. Current plans for 1984 provide for the processing of nearly 2,000 tons of the above-listed salts, parallel with the TPFS, but their output is certain to continue its increase.

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ROMANIA

NEW STAGE IN TECHNICAL-SCIENTIFIC REVOLUTION EXAMINED

Machine-Building Industry Progress

Bucharest ERA SOCIALISTA in Romanian No 19, 10 Oct 84 pp 11-13

[Article by Ion Crisan, general director of Central Machine-Building Institute]

[Text] In his address delivered at the solemn session commemorating the 40th anniversary of the revolutionary act of 23 August 1944, Comrade Nicolae Ceausescu stressed that during the new 5-year plan there will be "sharp intensification of scientific research, acceleration of the pace of introduction of technical progress, and increase in the contribution made by the latter to modernization of the economy and increase in the efficiency of all economic activities." To this end, the draft directives of the 13th Congress of the party point out that application in production of the latest accomplishments of the technical-scientific revolution represents "a decisive factor in development and improvement of material production and in assuring all-round progress of society as a whole." Emphasis is thus placed on the fundamental role of technical progress in socioeconomic development, and at the same time on the mandatory nature of speeding up technological progress in the context of the development process.

As is known, the machine-building industry is one of the industrial sectors with the highest sensitivity to the current technical and scientific revolution. Precisely for this reason do I wish to stress that, in making a correct evaluation of the priority objectives of its development, it is especially important to take into account the objective trends of general technological progress.

Employing a classic formula, I would say that new technology resolves the contradiction between the needs and the capabilities of old technology. New technology is developed under the pressure of unsatisfied needs; when it appears, these needs are better satisfied, but at a certain stage of development the contradiction reappears, ceaselessly bringing about new improvements. We can conceive of technological progress as a triangular system in which invention, technology, and necessity are interdependent, but in which invention is transformed into technology only under the impetus of social necessity.

Examination of the forms in which technological progess is manifested reveals that the evolution of a technology conforms to a performance-over-time diagram divided into a preparation zone, in which knowledge that does not yet show visible effects is accumulated, a utilization zone, in which the performance achieved increases, and a final zone, in which growth ceases. Over a protracted period of time the evolution appears to be discontinuous, as a sequence of several performance curves intersecting at increasingly high levels.

In the trace of the performance-over-time curve of any technology, at a particular time a "revolutionary stage" appears which corresponds to a very sharp increase in the performance of the technology in question. In particular, the points of intersection of the curves representing increasingly improved technologies, that is, "inflection" points of transition from one technology to another much more efficient one, mark the beginnings of periods of the nature of a technological revolution.

The evolution of these overlapping "technological stages" in my opinion underscore the "synergic" (cumulative interdisciplinary) nature of technological progress, the fact that such progress is based on the addition of new components to those already known. The series of these stages in effect begins with the paleolithic, with the simple tool which over time is transformed into a combination tool later becoming a machine. Our century has been that of creation of the programmed machine, the machine with a memory: initially mechanical memory, then electromechanical and electronic, and finally reprogrammable memory. The last two decades of this century will be marked by the appearance of unassisted technological systems, flexible automatic systems made up of a number of subsystems performing various functions.

I believe a practical inference to be drawn from the foregoing is the great topicality and importance of exploiting the "synergic surplus value" as a way of increasing the value added in the process of manufacturing machines, of realizing the surplus value created by addition of a supplementary innovative element to a new technological system form by recombination of known components. Of course, this "surplus value" does not come into being of itself. The engineering of large systems, so-called "macroengineering," today resorts to new knowledge and instruments, bringing about a trend toward institutionalization of advanced forms in the organization of industry, in which flexibility or ability to adapt, involvement of several disciplines, and access to information play a primary role, and scientific research is a component whose share continually increases.

Precisely for this reason, in my opinion, does the ability of the machine-building industry to produce complete technological systems, not just individual machines, under current conditions, at the same time providing the services necessary for their commissioning and even activation, represent an essential resource for increasing efficiency. This conclusion sheds a special light on the provisions of the 13th Congress draft directives relating to "creation of systems of machinery and equipment of modular and multipurpose design through structural unification of elements and

subassemblies, development of the production of standardized components, especially electronic, microelectronic, pneumatic, and hydraulic ones."

However, achievement of technological development revolutionary in nature does not depend exclusively on correct identification of the technical solutions on which technological progress in different sectors is based. It is not enough to have knowledge of a particular technology. Technological progress of a revolutionary nature is accomplished only if new technologies are applied in a sufficiently short time. Consequently, I consider the problem of learning time to be the second important aspect of promoting new technologies.

While the forms of technological progress fit into a clearly defined sequence, the unfolding of the application process depends not on just one "determining factor," but on a great number of factors exerting their effect over the entire period, from laboratory testing of a prototype to preparation for production, in series production, and later in operation. I believe it to be important to stress that, in the especially complex circumstances of of current technological progress, the application of these factors requires not only acquisition of new machines, materials, or skills, but often also the creation of complex systems incorporating as efficiently as possible the action of numerous elements involved in proper operation of the whole.

To illustrate these ideas I offer two examples characteristics of the current stage of the technical and scientific revolution in the machine-building industry. The draft directives of the 13th Congress speak of "large-scale development of fully computerized and robot-operated lines, sections, and sectors." For the machine-building industry this task entails chiefly penetration of computerization into the sphere of medium-sized and small-series production, in which the conventional computerization solutions, the well-known "rigid" automata, cannot be used economically.

The new stage in the technical and scientific revolution "was announced" about 20 years ago, at the time of appearance of numerical program control.

A punched tape in which the machining program was recorded assumed full control of a machine tool similar to the conventional ones. The entire machining cycle is performed automatically, without error and with high accuracy. Transition from one piece to another different piece requires only changing the punched tape in the electronic control system. This was the first step toward flexible automation of machining by metal cutting. As time passed, the system was improved: the punched tape was replaced by a microcomputer, which assumed not only control of a large number of programs, without changing a tape, but also monitoring of other process parameters such as tool wear. A system of blades was added which permitted automatic gripping and release of the piece on the machine. An automatically changed tool magazine was added. Several such machines were coupled together to create systems performing completely automatic machining of pieces of high complexity.

As part of the consistent effort to outfit our machine-building industry with the most advanced technology, many enterprises have been provided with

such equipment. For many enterprises this equipment has provided the basis for truly revolutionary progress in improving labor productivity and quality. In other enterprises, unfortunately, the same results have not been obtained. In my opinion, the cause is represented by the fact that sufficient attention has not always been paid to creation of the "system" necessary for application of new technology, a system in which the numerically controlled machine represents only the "determining factor," the other factors being (1) assurance of proper maintenance of electronic and hydraulic equipment; (2) provision of tools and presetting them away from the machine, to avoid machine down time; (3) provision of a sufficient number of "programs" and creation of a program verification system before the programs are introduced into the machine.

I should like to deal at greater length with the third condition, since it represents an entirely new element in mechanical technology. Programming the numerical control of machines is a new craft requiring combined technological and data processisng knowledge, as well as outfitting with suitable computer equipment. In my opinion, sufficient attention is not always devoted to training of computer programmer personnel and the proper utilization of such personnel. In some cases this situation has led to certain deficiencies in efficient utilization of numerically controlled machine tools, and also to delays in transition to development of more complex flexible automatic machining systems. It is encouraging that, as a result of provision of more computer equipment and good cooperation between technological institutes and enterprises, automatic computer-assisted programming has now been greatly expanded and significant progress has been made in integrating the design of complex pieces and computer-assisted design of the machining process. I nevertheless feel that extension of these methods should be greatly speeded up.

A similar situation exists with the problem of introducing industrial robots and manipulators. Application of this new production technique can result in automation of processes conventionally considered to be manual processes (such as transfer of pieces from one machine to another, arc or spot welding, handling of pieces in forging or heat treatment, painting and metal spray coating, etc).

A number of representative applications have been developed at institutes and enterprises, and several types of robots and special-purpose manipulators are now undergoing testing. Despite this fact, the progress that can be made with robot technology, in my opinion, still has not been realized to the full. The number of applications is still small, and some technologists imagine that by introducing a robot into a factory they can immediately accomplish automation of a proçess. In reality, it is necessary everywhere to create a suitable technological system, and above all to make suitable preparation for the technological process which is to be automated by means of industrial robots. A robot may not be instructed otherwise than in error-free fashion. It does not allow defective pieces and does not know how to take "remedial steps." An efficient system cannot be obtained by installing a robot to service machine tools which break down frequently. Generally speaking, robot technology necessitates particularly important

preliminary work and the creation of well-tested conditions devised by engineers.

I believe that imparting revolutionary dynamics to technical progress, an essential requirement pointed out on many occasions by Comrade Nicolae Ceausescu, secretary general of the party, must be accomplished both by seeking out the new and by creating conditions for increasingly large-scale application of the enormous volume of technological knowledge which mankind is accumulating. To this end, the new stage in the technical and scientific revolution entails and will increasingly entail advanced engineering creativity, which does not remain in the laboratory but persists until its fruits become an asset of the entire people. In our days, when technology is developing at an unprecedented pace, the dividing line between "development" and "application" is gradually disappearing. Moreover, in the critical fields the laboratory is being transformed into a factory and the factory into a laboratory. Consequently, bold promotion of science and technology above all means investment in creativity.

Over the last four 5-year plans the Romanian machine-building industry has set an eloquent example of promotion of investment in creativity, primarily through development of integrated systems of scientific research and technological engineering both at the national level, through the National Council for Science and Technology, headed by Academician Dr Elena Ceausescu, a scholar known and esteemed throughout the world, and at the level of every sector and subsector of the economy. Thus, in the machine-building industry development of the Scientific Research and Technological Engineering Institute in the field of petroleum equipment has resulted in creation of the potential necessary not only for diversification of petroleum equipment production in Romania, on the basis of original Romanian research search and development, but also for critical research such as that on computer control of drilling processes or introduction of designs of high wear resistance for extraction pumps. At the Research Institute for Machine-Building Technology, significant results have been obtained in creation of automatic installation systems and new machines for non-conventional machining, and in computer-assisted design of machines and mechanisms. In a number of institutions new installations have been activated for improvement in the means of scientific investigation and experimental research, such as in the field of heat engines, refrigeration machinery, noise and vibrations, etc, of original Romanian design.

In my opinion, an important component of the "investment in creativity" is represented by measures to provide reserves of research personnel and constantly to improve the qualifications of such personnel. The research worker employed in a revolutionary manner in high-level creative work must without fail be an enthusiast. But his enthusiasm must rest on a solid foundation of knowledge in his specialty. In recent years, a large number of young graduate engineers who have worked 2 to 3 years in production, and who had high grade averages at graduation and an aptitude for research and development work, have assumed technological research and engineering positions at enterprises and institutes. The criteria adopted in selection of these personnel were primarily the level of basic knowledge and the

flexibility of thought, the idea being that an aptitude for assimilating the new is especially important for a research worker constantly in contact with rapid technical progress. The day-to-day work experience with these young cadres has proved just how important this aptitude is. Considering that knowledge in a given technological field becomes obsolete in 5 to 6 years and must be brought up to date, the highest importance is attached to constant training given to all the personnel of the research and development institutes and sectors of enterprises. The management personnel with experience in such units consider their educational obligations, both from the strictly professional viewpoint and as regards improvement in aptitudes for communication, creativity, and daring engineering thinking, to be not only a moral obligation, but also a highly important means of increasing labor productivity and general efficiency and of constantly improving scientific research and technological development activities.

Electronics Potential, Data Processing

Bucharest ERA SOCIALISTA in Romanian No 19, 10 Oct 84 pp 13-17]

[Article by Mihai Draganescu, general director of Central Control and Data Processing Institute]

[Text] The new stage in the scientific and technical revolution is a worldwide process, essentially a technological revolution based on microelectronics, data processing, automation, robotics, artificial intelligence, and communications. However, as is pointed out by Comrade Nicolae Ceausescu, it also has significant industrial, economic, and social consequences. In an interview granted in August 1984 to the French publication LA REVUE PARLAMENTAIRE, the secretary general of the party stated that "we wish to commit all our resources to achievement of the new industrial revolution, by which I mean the material and scientific resources currently available to us. We are doing everything, naturally also cooperating with other countries, to bring about Romanian participation in modern development, on the basis of development of electronics, introduction of robotics, and general automation of production processes.

In view of the foregoing, we consider thorough analysis of the new revolutionary processes in science and technology and of their impact on economic development and society in general to be of cardinal interest. In addition, a number of aspects and implications of the technical and scientific revolution have been discussed in Romania in recent years, on the basis of the guidelines and directives established in party documents, examination being made simultaneously of new processes determined by the enormous strides in the fields of microelectronics and data processing.

The draft directives of the 13th Congress state expressly that "the electronics industry will penetrate all economic and social activities on a large scale." The stressing of the highly important role in a party program document is fully justified, in view of the innovative potential of this field, a potential determined by the performance achieved by elements the priority development and production of which are planned in Romania as well: electronic components, automation equipment, industrial and

professional electronic equipment, computers, minicomputers, and microcomputers for control of industrial processes, and peripheral equipment.

Electronics affects all of technology, in all its diversity, and through it the economy and society as a whole. The chief directions in which electronics itself is evolving today depend on essential factors such as (a) microelectronic components in the form of integrated circuits, on an ever larger scale; (b) the data processing programs whereby the information functions of electronic equipment are performed, and through them the functions of technical systems in keeping with industrial and social needs; (c) complex technical systems made with the elements previously mentioned; (d) the new relationship of man to technology determined by the informational interaction between the two "partners"; and so forth.

The potential offered by microelectronic technology for producing a computer on a single chip of silicon, and in the future even several processors on the same chip, at an ever lower cost and in an operating arrangement ensuring very high performance for the unit as regards speed (that is, response time) and the nature of the problems that can be solved, foreshadows the very powerful potential and the economic efficiency of the informational tools which will be available to society in the near future. Data processing permits the creation of "intelligent" programs, especially ones of expert systems, for various domains of scientific knowledge and technology, including research and development and control of complex systems. This gives a picture of the role played by artificial intelligence, as Stefan Odobleja said, in augmenting man's capacity for intellectual work and, ultimately, the social intelligence of the human labor collective.

Hence it may be quite confidently stated that humanity is entering a new technological stage clearly manifested in the process of industrial application of robotics. But this represents only one aspect of a broader process, that of flexible automation or computerization of production, in which the robot becomes a tool with data processing capabilities of its own, a tool included, along with other machine tools, apparatus, and handling equipment, in a system making decisions based on computers and data processing programs.

All technical and economic progress is thus increasingly closely linked to the development of electronics, data processing, and automation. A number of products in these fields, as well as their applications, were presented at the Economic and Social Development of Romania Exposition. They demonstrate the ability of our people to create and to make increasingly efficient use of new technologies. We consequently feel that the time has come for examining any form of industrial reality both from the viewpoint of its energy and materials structure and from that of its data processing structure, together with its electronic supporting equipment. These two structures function in increasingly indissoluble symbiosis, and accordingly their research and development will have to be closely coordinated. As a result, there will be a gradual transition to investments of the flexible production type, which will cost no more than conventional investments, and to redesign and retooling, in accordance with the new technological

principles, of the conventional production and assembly lines. The draft directives state that during the forthcoming 5-year plan priority will be assigned to flexible systems and cells for manufacture of articles, and in a later period transition will be made to flexible assembly cells as well.

It is apposite to note that socialist industrialization has been accomplished in Romania essentially on the basis of the achievements of the first industrial revolution, under the conditions of a particular stage of development of world technology. At the same time, the creation and development of socialist industry have also derived the benefits of the last phase of the first industrial revolution, the phase of electric energy, electrical engineering, and applications of electromagnetism, our socialist society then proceeding to develop the elements of the contemporary scientific and technical revolution. All these stages are beginning, however, to lag behind the cutting edge of technological development. Hence the guidelines in the field of technological development contained in the draft directives of the 13th Congress are fully justified. The change in the nature of technology from the physical to physical plus informational and informational alone can legitimately raise the question of whether or not there is need for modification of the theory of socialist industrialization or for its adaptation to the new conditions. The fundamental change in the nature of technology and the consequences of the transformations taking place as regards the nature of productive forces, human work, and economic and social life will result in transformation of the microelectronic and data processing technological revolution into a veritable industrial revolution, the second in the history of mankind. While the first industrial revolution was a revolution of industrialization of man's physical strength, the second industrial revolution will, in our opinion, be a revolution of man's informational capacity and intelligence.

For example, a new factor which we believe must be taken into account is the extension of industrialization into domains which until recently were not of an industrial nature, a number of activities of intellectual content, part of the service sectors, education, and medicine, to say nothing of a fresh intensification of the industrialization of agriculture. It is true that this extension of industrialization will take place within the context of a new type of industry based on equipment itself of a new nature and based on institutional concepts at the level of society as a whole, on a type of organization of labor allowing for specific differences as regards the pace of activity, over time, between living, biological man and technical tools and systems. Under such conditions the industrial structure is faced with new problems, primarily because of the new qualities appearing within the context of industry, and secondly because of the new quantitative relationships arising among the spheres of an industry characterized by a much broader spectrum of inclusion.

Remaining at the level of an economy based on the achievements of the first industrial revolution, with the entire sequence of innovative extensions following in its wake, unquestionably means a new form of underdevelopment capable of affecting not just the economic level, but also the cultural and

spiritual level, including the quality of life of a people. There can be no going backward and no consolidation of the old, through rigidification. The only way to go obviously is forward, in step with the times, and in some cases even moving ahead of them to contribute to acceleration of progress. This is the message recorded in the draft directives of the 13th Congress, and we can only support them will full conviction and confidence. We would at the same time recommend that the draft directives formulate more specifically also the objectives relating to the data processing program industry, utilization of electronics and data processing in research and development activities, and industrial data processing in general.

The electronics industry must be developed, and at the same time electronics must be applied on a larger scale, in order to carry out the new stage of the scientific and technical revolution in Romania, in accordance with the draft directives of the 13th Congress of the party. In our opinion, this requires initiation of a cylce having the following phases: (a) ensuring of rapid technological progress in the sphere of microelectronics, and of electronic components in general, leading to (b) lower cost of electronic components and equipment. This will result in (c) a heavier demand for electronic components and equipment in a wide variety of fields, something which in turn will lead to (d) increase in the production of electronic equipment, and then to (e) lowering of costs due to the greater production volume, so that there will again be need for (f) scientific research and technological engineering for the purpose of making technological progress and repeating the entire cycle. Romanian specialists have particularly valuable accomplishments to their credit in this regard. We believe that they have even now demonstrated their creative ability to cope with the problem of bringing about exponential growth of electronics and allied fields that can be supported naturally only by a cycle such as that referred to, which is a self-sustaining one.

Electronics is itself undergoing a radical transformation because of computers, and computers cannot function without data processing programs. Consequently, data processing will play an important role along with electronics in the new stage of the technical and scientific revolution. The demand for electronic equipment for a wide variety of applications and industries will also entail a demand for data processing programs. Ultimately, the principal functions which electronic equipment is called upon to perform are supported by data processing programs. Electronics and data processing are thus becoming general infrastructures of industry.

Data processing has made significant progress in Romania as well, and it is prepared to participate in the new stage of the technical and scientific revolution. The process of extending data processing technologies to the scale of the country as a whole, transition from economic data processing to technical production data processing and industrial data processing for autonomous control of production processes, the construction, now in progress, of the national computer and data transmission network, the development of data processing (computer-assisted) research and development--all these new elements, which all came into being when activities in the domain of data processing were placed under the guidance of the National Council

for Science and Technology, headed by Academician Dr Elena Ceausescu, are closely coordinated with the provisions of the draft directives of the 13th party Congress.

Electronics, data processing, automation, and communications are progressing in close symbiosis. Their organized penetration into industry and economic and social life presupposes suitable action, the existence of teams of specialists or specialized work formations at enterprises concerned with introduction of new technical and scientific achievements, with rethinking manufacturing systems, technologies, and products for the sake of exploitation of the enormous technical and economic potential currently offered by these crucial fields.

All the other technological areas are unquestionably important, but at present we must deal with the problem of this new factor, this common denominator of all technologies, which is added to the already established factor of mechanics and machinery. This new common substratum is essentially of an informational order, and we are firmly convinced that gradually all of society, not just industry, will assume an informational orientation.

All Romanian workers employed in the fields of electronics and and data processing are firmly resolved to contribute through their sustained efforts to accomplish transition to what Comrade Nicolae Ceausescu, secretary general of the party, has defined as a new stage in the development of Romania, on the basis of a new industrial revolution, so as to achieve, through vigorous growth of the productive forces of society, a new and superior quality of work and life, elevation of our country to ever higher levels of socialist and communist civilization.

Unity Between Science, Production

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[Article by Marin Ivascu, general director, Central Institute of Physics]

[Text] Our party's strategy of implementing the program for building a comprehensively developed socialist society and advancing Romania toward communism assigns scientific research and technological development a decisive role in progress and stimulation of the economy and the entire life of Romanian society. "Creation of a developed socialist society is inconceivable, communism is inconceivable," points out Comrade Nicolae Ceausescu, secretary general of the party, "unless they are based on the latest achievements of science and engineering and the latest achievements of human knowledge in general." Proceeding from these considerations, the draft directives of the 13th Congress of the party stress that during the 1986-1990 Five-Year Plan Romania will enter a new and higher stage of its economic and social progress, heavily marked by increase in the role of science and technology in all spheres of activity, with scientific research substantially increasing the contribution it makes to promoting technical progress throughout the economy and in the life of society.

National scientific research is currently assigned such a decisive role and such major tasks and objectives precisely as a result of the high level of development and maturing of such research, deriving from the policy elaborated and implemented by the Romanian Communist Pary over the nearly 20 years that Comrade Nicolae Ceausescu has been guiding the destiny and aspirations of the country. The basic principles defined by the 9th Party Congress, the topicality and deep significance of which have been fully confirmed by life, are instructive for understanding the role, importance, and significance of this policy. Thus, the principle of the need for developing national research was established in the report presented at this historic congress by Comrade Nicolae Ceausescu. In this spirit, at the national conference on scientific research and development in October 1974, the secretary general of the party pointed out that "for a long time an erroneous conception has predominated in connection with scientific activities in Romania. There have been opinions that there was no need for us to concern ourselves with research, especially in the technical fields. According to these opinions, it would have been better to spend money to import foreign licenses rather than on research. Unfortunately, for a long time this course was followed. This erroneous orientation unquestionably had a certain negative influence on the development of scientific research activities." The correctness and soundness of this view elaborated by Comrade Nicolae Ceausescu on the need for developing Romanian scientific research have been, and are still being, fully demonstrated by the unprecedented upsurge of our entire economy and the rapid and steady elevation of the material and spiritual standard of living of the entire people.

Another major principle of the strategic policy of the party in the sphere of science, developed and comprehensively substantiated by Comrade Nicolae Ceausescu, is the development of this policy as an important productive force. As long ago as 1968, the secretary general of our party pointed out that "scientific research must be consistently examined from the viewpoint of its efficiency in increasing the material and spiritual wealth of the people. It is necessary to strengthen the link between science and production, so that what is discovered in the field of research will also be applied in production. Production, in turn, must constantly impel scientific research forward, continually demanding that it solve new problems." In accordance with this principle, science and technology represent production forces of the first importance in ensuring rapid increase in the national wealth and in raising the standard of living of the people, for the sake of strengthening national independence. Scientific research, technological development, and production must be indissolubly linked together, since this represents an essential condition of the economic and social efficiency of research. Research must boldly grapple with new, current and future, problems, substantiate the theoretical basis of all activities, and contribute to solution of the complex problems arising in the process of economic and social development of society. The results of research should be introduced as promptly as possible into practical activities, with the most valuable accomplishments disseminated and extended to the level of the entire economy.

I should like to mention at the same time the major principle of planned execution of research activities, a principle which has been consistently

promoted by our party. This principle involves establishment of clearcut trends of research activity, the existence of annual and 5-year plans and of long-range forecasts, and national coordination of activities in different fields of research, in the context of the current world technical and scientific revolution. Referring to this question, Comrade Nicolae Ceausescu stated in his address to the June 1984 meeting of the Supreme Council of Economic and Social Development of Romania, that "a new stage or a new technical and scientific revolution is being foreshadowed worldwide; it will cause profound changes in the industrial and economic structures of countries, in the development of human society, and accordingly must be appropriately reflected in the development of Romanian socialist society."

Firm application of the principles in question offers the certainty that Romanian science will continue to make a remarkable contribution to enhancement of the value of the current scientific and technical revolution, and also to utilization of its achievements in all sectors of the work and life of the nation. As is stated in the draft directives of the 13th Congress, this represents a fundamental condition for transition to a new quality in the forthcoming 5-year plan.

In the current stage the technical and scientific revolution represents the starting point for a new industrial revolution. What I should like to stress very heavily is the fact that the new technical and scientific revolution now in progress is sustained by an entire array of technologies which are generating and developing new technical and industrial fields.

In the context of such concepts calling for symbiosis, indissoluble unity of science and production, and organic introduction of science and technology into all of material production, the role and tasks of research in physics are among the most important ones, since, on the one hand, physics is, because of its subject and content, a branch of science which reveals the laws and supplies the information necessary for the appearance or development of other fundamental sciences, and on the other, physics has provided and will continue to provide the basis for development of a large number of technical sciences, such as mechanical engineering, aerodynamics, electrical engineering, electronics, etc, or of various techniques and technologies discovered and developed within the framework of physics, initially designated as nonconventional but later leading to the establishment of independent fields after they have matured.

There are a number of new achievements of physics which may be regarded as sources and nuclei of the new stage of the technical and scientific revolution. For example, beyond the achievements of physics thus far there are the promising research in and technology of microstructures, which are especially instructive in the sector of microelectronics. As a matter of fact, microelectronics has evolved through progressive decrease in the size of electronic components. Every 3 years the size of electronic components has been cut in half. If this trend continues, and we have no reason to believe that it will not, by the year 2000 it is to be expected that the most representative microelectronic devices will have dimensions of the order of millionths of a millimeter. In addition to this penetration into the

microcosm, the technologies in question are also greatly broadening the area of application of integrated circuits in a great variety of fields. Without assuming that the penetration of microstructures will be as spectacular in all cases as in microelectronics, we must nevertheless consider it to be certain, in my opinion, that the time of rating an industry merely by output tonnage is coming to an end and that, to be competitive on an international scale, the economy must base future development primarily on new "families" of technologies.

Returning to microelectronics, I should like to point out that, as new devices become smaller, special technologies must be applied for their manufacture. These are technologies which until recently were used, or are still used, only in physics technological laboratories. In effect, we are descending deeper and deeper into the nether strata of matter, reaching dimensions which may be termed the "infinitely small of the world of physics."

The factors that will determine the ultimate limits of operation of very small electronic devices are not as yet known, but at any rate we are heading toward the zone of biological processes which are due to transfer of electrons on a scale below a millionth of a millimeter. Of course, we are still a long way from reaching such dimensions or from creating structures of a complexity comparable to that of biological ones. It is nevertheless to be seen that organic molecules will play an essential role in future electronic devices. Even now scientists are considering application of the new discoveries in the domain of microstructures to reproduction on the same scale of the organs of smell and sight, and even to the creation of nerve tissue. Since neither the theoretical models nor technological performance have yet reached the level required for materialization of this very bold thinking, it is to be expected that over the next decade much enthusiastic effort will be applied to such research.

Just as important are the studies relating to surface physics, knowledge and application of the phenomena specific to the surface of a solid and understanding and using surface magnetic effects. We anticipate in the near future a great abundance of theoretical results and experiments connected with this field, and at the same time with acceleration by them of revolutionary processes in science and technology. For example, a prominent place in condensed state physics will be occupied by technological research to obtain materials for production of solar cells. The maximum energy yields currently obtained with various materials are 20 to 25 percent. What are needed are new materials, among which plastics are assuming an increasingly prominent position. The pace of this research will certainly increase, and ever greater efforts will be applied, since society has need of solar energy.

Research on the phenomena of superfluidity and superconductivity offers great promise. We understand the phenomenon of superconductivity to mean the property of reduction to zero of the electrical resistance of metals and metal compounds when the temperature drops to the area of absolute zero. What is involved is transition of matter from one state to another, from

possessing certain properties to possessing others characteristic of phenomena which may be extremely useful in meeting certain needs of society (loss-free transmission of electric energy, construction of high-energy accelerators and systems for conducting the process of controlled thermonuclear fusion, development of new common transmission systems, etc).

One of the most prolific and dynamic sectors of physics over the last decade was quantum optics. Having created a general-purpose instrument such as the laser, this sector will continue to advance toward increasingly important accomplishments, especially in the domain of optical communications, in numerous branches of industry, in biology and medicine, etc.

A number of studies have led to the virtually unanimously accepted conclusion that a highly promising solution for meeting man's energy requirements to the end of this century and in the next century is represented by energy of nuclear origin resulting from processes of fission and fusion. Establishment of nuclear energy in this domain in Romania of course requires a high concentration of technical and technological forces for development of equipment and for production of nuclear fuel and the heavy water required by this method. As is known, the directions, dimensions, and pace of this activity were established by the 12th Congress of the party. It goes without saying that technological research and national industry will have many complex problems to solve in the future in connection with nuclear energy.

However, research in physics also has the obligation of preparing solutions for long-range strategies. Under such conditions, physicists must be involved in studies in the stage of basic research, such as that on production of superheavy elements.

As regards Romanian research in nuclear physics and nuclear energy, as a result of the permanent support given by our party, its secretary general, and Academician Dr Elena Ceausescu, chairwoman of the National Council for Science and Technology, it is heavily committed to reaching important goals connected with broadening the energy base of the country, better use of raw materials resources, and improvement in the quality and competitive ability of products.

As a result of the measures taken to concentrate effort on priority goals, 65 percent of all the activities of specialists in the field of physics is devoted to participation in the nuclear energy program. Industrial-scale production of dosimetric apparatus and nuclear equipment was undertaken as early as 1983, ensuring a high degree of integration of products of this specific nature, even in the first nuclear generating set.

Another essential component of activities in physics over this period and during the forthcoming one will be design and building of new apparatus, equipment, and installations, as well as elaboration of technologies based on phenomena and processes of nuclear physics. The majority of these methods and techniques have been developed under contracts with economic units. We may give as examples methods for determination of the gold, silver, and copper content of lean ores; control of and increase in the factor

of final recovery from petroleum deposits; and use of stable and radioactive isotopes to determine the circulation of phreatic water. These are all techniques which will have ever wider and more efficient applications after they have been introduced into the national economy.

According to the draft directives of the 13th Congress, research in physics has goals of wide scope assigned to it in both applied and technological research and in basic research. Above all there are the tasks resulting from the national nuclear program, the programs specific to physics, and the interdisciplinary programs coordinated by the National Council for Science and Technology, such as the program for new energy sources, the high magnetic field program, the laser and laser application program, and the vacuum techniques and technologies program, the special materials program, the nuclear engineering apparatus and applications program, the heavy ion physics program, the program of radioactive isotopes and tagged and radioactive pharmaceutical compounds, the radiation dosimetry apparatus and technology program, etc. Objectives in the area of nuclear power engineering are construction of nuclear power plants operated with natural uranium and heavy water, the development of allied industries in the system of the State Committee for Nuclear Energy and in other ministries, the development of advanced nuclear power reactors operated with thorium, regenerative nuclear power reactors, production of new nuclear fuels, and development of research on the nuclear power reactor line based on controlled thermonuclear fusion. Technologies for increasing and controlling quality in general and nuclear quality control in particular will similarly represent one of the essential objectives of nuclear physics, which will thus contribute to production of the class of apparatus and installations needed for obtaining high quality under strict material and energy conservation conditions, without special effort on the part of the labor force.

As has been pointed out on a number of occasions by Comrade Nicolae Ceausescu, research has the task not only of solving the problems of today, but also that of anticipating the solutions and resources of the future through its discoveries. For this reason, proper attention will be paid to basic research in physics. I may cite as examples three allied fields derived from nuclear physics: the physics of heavy ions, relativistic nuclear physics, and the physics of elementary particles, from which discoveries of great significance and depth are expected in the years to come.

Because of the scientific, technical, and technological results which it obtains, and because of its application in socioeconomic activities, physics performs a cardinal role in effecting the transition to a new stage of the technical and scientific revolution, this transition representing the basis for the indestructible symbiosis of science and production and improvement in the production of material goods, in keeping with the demands of economic and social progress.

Scientific Research Aids Agriculture

Bucharest ERA SOCIALISTA in Romanian No 20, 25 Oct 84 pp 12-14

[Article by Tiberiu Muresan, president of the Academy of Agricultural and Forestry Sciences]

[Text] Foreshadowing the major progress to be made in the social and economic development of Romania under the forthcoming 5-year plan and to the end of this century, the draft directives of the 13th Congress, drawn up under the direct guidance of Comrade Nicolae Ceausescu, secretary general of the party, represent a priceless instrument for implementation at an ever higher quality level of the party strategy for creating a comprehensively developed socialist society and communism in Romania. Because of their profoundly scientific conceptual foundation and their concrete provisions, which take the objective requirements of progress into account, the draft directives in essence represent a broad and comprehensive program of work, a precise and efficient program in which prospects for rapid development, in an optimum relationship with industry, are opened up for agriculture, along with the other sectors, in the process of modernization. This process, initiated by the 9th Congress, is the most convincing demonstration of the agrarian policy of the party in the harmonious general strategy of social and economic development. This is attested by the fact that a grain production of 1000 kilograms per inhabitant was reached in 1982 for the first time in the history of the country, and by the high wheat harvests in 1984, a year marked by unfavorable weather conditions.

As is known, 216 agricultural units holding nearly 160,000 hectares reserved for wheat growing harvested more than 5000 kilograms per hectare. Prominent in this picture of achievements are the units situated in different areas of the country which managed to produce 6000 to 7000 and even more than 8000 kilograms per hectare on nonirrigated land. Results such as these are particularly instructive. On the one hand, they provide uncontrovertible proof of the production potential of our socialist agriculture, and on the other they illustrate the contribution made by scientific research, which over the last 2 decades has succeeded in creating varieties and hybrids of high biological value, in producing seeds of superior categories, and in elaborating cultivation technologies and soil improvement systems.

The increasingly close unity of research and production, based on the fruitful principle of integrating science with activities in agriculture, represents one of the essential aspects of the new agrarian revolution, whose theoretical and practical foundations have been laid in a magisterial manner by Comrade Nicolae Ceausescu. In the view of the secretary general of the party, accomplishment of the new agrarian revolution is the expression of an historic necessity, that of making the transition to a new quality embodied in agriculture through substantial increase in crop and livestock production and through substantial increase in economic efficiency. An essential role is assigned to scientific research in this complex process. "Highly productive agriculture is inconceivable without

scientific activity at the highest level," Comrade Nicolae Ceausescu has pointed out, with full justification. This is the source of the highly responsible tasks assigned to agricultural science over the forthcoming period, which will be characterized by new and vigorous growth in all sectors of the national economy.

According to the draft directives, by 1990 grain production is to reach 30 to 33 million tons, and significant increases are also planned for other crops. As a result, gross agricultural output will increase at an average annual rate of 5.4 to 5.8 percent, while livestock raising will develop at a pace such that it will account for 46 to 48 percent of total agricultural output. As is pointed out in the draft directives of the 13th Congress, in order for these targets to be reached, "Romanian science will have to increase its contribution to development of agriculture on a modern basis and to achievement of dependable and stable high yields, regardless of variation in climatic factors. New plant varieties, more productive and hardier, and new stock breeds of greater feed assimilation capacity ensuring higher yields will be created on the basis of applied biology and genetic engineering. Solutions will be found for reclamation of unproductive land and its return to the agricultural cycle, optimum zoning of production and integrated mechanization of operations, and efficient utilization of the irrigation system and other land use facilities."

As thus formulated, the tasks assigned to agricultural research give evidence not only of a profound realism, but also of an especially clear-sighted anticipation of the future development of science, under the conditions of the new technical and scientific revolution. This is especially important because during the forthcoming 5-year plan research is to prepare, at least in part, the means and methods of agricultural practice for the last decade of the century, by which time it is estimated that Romanian agricultural output will have increased by a factor of 1.9 to 2, grain production being stabilized at a level of at least 35 million tons annually.

An essential objective of activities in the domain of soil science and agrochemistry will be finalization of research on inventory and complex characterization of new resources for increasing the agricultural and arable land of the country, substantiation of the plans for use of chemical and organic fertilizers, and improvement in soil amelioration measures and intensive agriculture systems.

In this connection an essential role is assigned to research on the evolution of soils and their quality as greatly improved by land reclamation projects, and pedologic substantiation of land improvement solutions. There will also be need for intensification of research on prevention and control of soil pollution, use of new fertilizers, waste materials, and sludge and waste water of livestock raising complexes to increase soil fertility, etc.

Particular attention must be devoted to establishment of integrated technologies for the most efficient possible utilization of irrigation systems, including rational water utilization and reduction of energy and labor consumption. In the area of drainage, an integrated research concept will be

promoted both for improvement in the technologies themselves and introduction into practice of all soil reclamation projects on drained land; these projects are designed to bring about improvement in the properties of soils and restoration and increase in soil production potential.

On the basis of the experience gained in controlling soil erosion, new problems arising in moist areas, in dry areas with irrigation systems, and in landslide zones will be dealt with. Within model district areas projects specific to individual zones will be carried out to test a great number of technologies, and a wide range of land reclamation and agrotechnical erosion control solutions will be applied.

All these objectives are an integral part of the Land Fertility and Health Program. The program is to be carried out in its entirety over the last decade of the century, this being an essential requirement for the possibility of obtaining dependably high and stable harvests. Full utilization of the productive potential of newly created varieties and hybrids will become possible in this way. This potential represents a great reserve for increasing harvests even as high as twice the level currently reached in agricultural units. As has been pointed out on many occasions by Comrade Nicolae Ceausescu, secretary general of the party, this entails increasingly active participation by research through elaboration of suitable technologies and their application in practice.

At the same time, research activities devoted to creation of more productive, earlier varieties and hybrids which are more resistant to diseases and climatic stresses will be continued and developed at a higher level of quality. These varieties and hybrids must also meet other requirements in the sphere of quality: they must produce high and constant yields, have a high content of useful substances, make better use of natural resources, and ensure higher efficiency in the process of transformation into a useful harvest of the energy invested in the form of fertilizers.

To give concrete expression to these trends in the sphere of both crop and livestock production, it is necessary to develop applied genetics research to create new varieties of plants and breeds of animals possessing much superior characteristics, and in some cases even vital characteristics not generated by nature. It is by no means impossible that in the future they will replace those known today, the biological potential of which has a certain limit beyond which it is objectively impossible to go.

As is pointed out in the draft directives of the 13th Congress, the new creations will be based on applied biology and genetic engineering, in a broad interdisciplinary and multidisciplinary context. The new achievements of science and technology create the possibility of transferring genes from superior animals or plants to easily cultivated bacteria. In this way various organic syntheses can be carried out, including synthesis of biologically active substances. This will cause radical transformation of entire industries (pharmaceutics, the food industry, extractive industry) and fields, such as human and veterinary medicine and animal husbandry. Thus, genetic engineering permits preparation, with high economic efficiency, of vaccines, industrial synthesis of hormones affecting animal size

and lactation, as well as a large number of other substances thus far very costly to obtain. The domestic production of enzymes as "instruments" of these new technologies entails intensified research in physics and chemistry, microbiology, etc, that is, integrated, multidisciplinary research.

Biological engineering, when used either in research or industrially, opens up broad prospects for agriculture, for example, by providing the possibility of reducing or replacing the nitrogen of chemical fertilizer in the future with biological nitrogen (through transfer of the complex of genes which control the production of enzymes necessary for fixing nitrogen, from the bacteria which possess it naturally to bacteria extensively present in the zone of influence of roots or through transfer of these genes directly to cultivated plants, especially cereals). This represents an objective of wide scope toward which world science has barely taken the first steps. Romania is also engaged in research in this field, with experiments conducted at the Fundulea Research Institute for Cereals and Industrial Crops. These experiments will be intensified in the future.

However, the tasks assigned to agricultural research during the next stage also have implications wider than those already referred to. They bear not only on the cultivation of cereals and other crops, but also on animal husbandry, a field in which significant increases are anticipated, research for the food industry, for utilization of renewable energy sources, etc.

We find ourselves, in fact, on the threshold of a new stage in the technical and scientific revolution, one which also has a direct bearing on agriculture, in essence leading to a qualitatively higher stage in its development. In our opinion, this necessitates improvement in the structure itself of scientific research in this field, so as to ensure effective increase in its role in the advancement of agriculture. "Accomplishment of the highly responsible tasks in the years to come, economic and social development of the country," Comrade Nicolae Ceausescu has pointed out, "requires sustained activity in the area of scientific research, a heavier concentration of the forces of research institutes, for the purpose of solving the technical and technological problems facing enterprises and the national economy, lowering consumption, and raising the technical and quality level of products."

Whatever the field considered, we believe that there is need for a more thorough approach to the problem of transferring the results of research to large-scale production. In its development characterized by powerful dynamism our socialist economy has generated structures and mechanisms capable of bringing the production levels reached in agricultural and livestock raising units ever closer to those achieved in research units. But the gap is still wide. That this gap can be reduced is demonstrated by the remarkable results obtained in many agricultural units. At the same time, however, other units are obtaining wholly unsatisfactory yields. The causes of this discrepancy have been clearly revealed by Comrade Nicolae Ceausescu, secretary general of the party. In the districts which have obtained yields below 3000 kilograms per hectare, in the case both of wheat and of barley, satisfactory action has not been taken, and the people's

councils, specialists, and agricultural authorities have not acted in the spirit of the responsibility assigned to them in the management of agriculture in the respective districts and have not taken all the measures needed for use of available resources, primarily land, equipment, and everything else that our socialist society provides to obtain appropriate harvests.

Our party and state devote the greatest attention and constant support, organizational, material, and financial, to agricultural research, and the basic conditions which society provides for the progress of agriculture also include the results of specialized research. Failure to apply these results, or merely partial or incorrect application year after year creates margins for increasing agricultural output, and they will continue to be "margins" until the agricultural units involved take action themselves, with the greatest resolution, to overcome routine and traditionalism from the technical and organizational viewpoints and until the specialists working in these units all do their duty to the utmost. As Comrade Nicolae Ceausescu has pointed out, "regardless of what mechanization, irrigation systems, or seed we may have, man is still the factor determining the harvest."

This great truth is equally applicable to specialists, research workers, who have the high mission of making a more substantial contribution to the activities of production units, and to workers in agriculture. The continuing development of mechanization, agricultural use of chemicals, and land improvement, as provided in the draft directives of the 13th Congress, will generate new needs for qualified personnel. To meet these needs, it will be necessary to involve 590,000 persons in the qualification and advanced training process during the forthcoming 5-year plan. And since the proportion of the population employed in agriculture will decrease to 27 percent, we believe it to be absolutely indispensable to resolve the question of the content of the instruction which the first future agricultural workers are now receiving and will receive. We are mindful that the new technologies developed on the basis of the methods of genetic engineering, tissue cultures, and integrated control of diseases and pests, will create new trades, or at the least will require advanced training to improve skills, and we must give consideration to this problem now, in a fully responsible spirit.

To the same extent that the new agrarian revolution is a revolution in engineering, it must be a revolution of conscience involving all who are active in agriculture, from the research worker to the laborer in the field. Armed with the ideology of the party, with ever broader scientific and practical knowledge, all persons working in agriculture have the obligation of making a conscious and responsible effort to raise this basic branch of the national economy to the level of productivity required for vigorous development of socialist Romania in the years to come.

Role of Chemical Research

Bucharest ERA SOCIALISTA in Romanian No 20, 25 Oct 84 pp 14-16

[Article by Prof Gheorghe Marcu, director, Institute of Chemistry, Cluj-Napoca]

[Text] In the general policy of our party of socialist industrialization of Romania, development of the chemical industry has been a priority goal especially over the last 2 decades, when, under the direct guidance of Comrade Nicolae Ceausescu, secretary general of the party, a powerful chemical industry has been built, one with a modern structure and oriented toward satisfaction of the acute needs of the national economy. As a result of allocation of substantial investment funds, over the 1965-1984 period more than 1800 units and production capacities having highly sophisticated equipment were commissioned in the chemical industry, and the variety of chemical products was greatly broadened. This development fostered active engagement of Romanian chemistry in the international economic cycle, the share of chemical products in Romanian exports reaching 25 percent in 1984, as against only 7.6 percent in 1965.

At the same time, the foundation has been laid for modern research in the field of chemistry and technological engineering, activities with which advancement of the chemical industry is closely associated. The prestigious results of the Romanian school of chemistry and the decisive role of applied scientific research in promoting new criteria are based on the remarkable scientific conception and activity of Academician Dr Elena Ceausescu, a world-famous scholar, who has consistently guided and oriented science toward the major problems of the national economy, establishing a new type of organization of work at the Central Institute of Chemistry, which has become the standard for all research activities in Romania. While guiding and directing the vast activities of fields of decisive importance for the progress and prosperity of the country, Comrade Elena Ceausescu engages in prestigious creative scientific activity of her own in the field of macromolecular chemistry, especially in the areas of polymerization, stabilization of synthetic rubber, copolymerization, and other fields. These pioneering projects, which have received unanimous acclaim abroad, are making important contributions to enrichment of the national scientific treasury and that of the world, being valuable reference resources in the critical sectors of modern chemistry.

The major tasks assigned to chemistry, as well as to Romanian science and engineering as a whole during the forthcoming period, which, as has been pointed out by Comrade Nicolae Ceausescu, will represent a new stage in the technical and scientific revolution, are marked out in the draft directives of the 13th Congress drawn up on the basis of the guidelines and instructions provided by the secretary general of the party. The directives basically call for emphasis of the intensive aspect of economic growth, on the basis of the current stage of economic and social development and with the extensive equipment and materials resources available to the economy. This is to be accomplished above all by raising the level of labor productivity and product quality in all sectors, espcially through introduction

of technical progress, automation, cybernitization, and robotization of production. Reaching these targets presupposes, on the one hand, better and fuller utilization of raw materials, on the basis of advanced technologies and modern equipment, and on the other lowering of the consumption of raw and intermediate materials, fuels, and energy, paralleled by energetic activity to reduce rejects and recover waste materials by including used materials and products in the economic cycle. In opting for this mode of development and progress, we must obtain increasingly improved products with superior technical and economic properties, in order to raise all economic and social activities to a new and modern level.

We believe that, as regards development and broadening of the base of raw and other materials of our society, chemistry has extensive capabilities for broadening its role as principal supplier of synthetic substitute products replacing natural ones, and also for ensuring better use of all raw and intermediate materials, with a lofty spirit of responsibility and with maximum efficiency. Thus, a sector which has very broad prospects for the future is that of synthetic fibers and filaments, plastics, and rubber. We believe that synthetic filaments and fibers, with properties superior to the natural ones, will play a vital role in the process of revolutionizing the textile industry. Because of the unlimited potential for producing new polymers, there will also be vigorous development of plastics, materials which have penetrated deeply and are continuing to penetrate into all technical and economic activities, from the machine-building industry to the electrical engineering and electronics industries, production of consumer goods, etc.

In the current stage of the technical and scientific revolution, an increasingly important place must in our opinion be held among the new technologies by the so-called "nonconventional" ones, which are entirely different from the current technologies inherited from preceding generations, are based on different principles, on another viewpoint, and are capable of opening up paths to a new technological civilization and of meeting the new energy criteria, as well as those governing total and better utilization of raw materials, competitive ability, and efficiency.

I should like to mention a sector of very high current interest and of great promise, the development of which in the years to come is planned in the draft directives. This is the sector of micro chemistry, which represents the basis for production of dyestuffs, auxiliary materials for industry, detergents, cantharides, drugs, etc. I believe that, generally speaking, research units as well should concentrate their attention increasingly on micro chemistry, since it offers numerous opportunities for carrying out industrial production of high value and low tonnage. Requiring an advanced degree of complexity and a significant volume of highly specialized labor incorporating an extensive content of scientific information, with a high degree of novelty and an appreciable amount original intelligence, the output of microchemistry is the best suited for a continuous process of innovation and optimization, diversification, and development.

In connection with the sector of microchemistry I should like to give an example of the activities of the Cluj-Napoca Institute of Chemistry, a component unit of the Central Institute of Chemistry. It involves the synthesis and production of pheromones, performance research initiated and further developed at the instigation of Comrade Nicolae Ceausescu, secretary general of the party, on the occasion of the visits paid to our institute together with Comrade Elena Ceausescu. The pheromones are substances in the group of exohormones, which are used in nonconventional methods of hormonal control of pests in fruit growing, forestry, viticulture, and cultivation of field crops, leaving the useful insects unaffected. They embody all the qualities of ideal insecticides. They are characterized by extremely high specificity, are completely non-polluting because of the lack of toxicity to warmblooded animals, and they can be used in unusually small quantities in the pest control process.

Acceleration of innovation and modernization of products and technologies to meet urgent needs of the economy can in some cases be accomplished more easily and rapidly even in scientific research units, through industrial production activities. I have in mind especially utilization of the results of research which, entailing much intelligence and difficult and complex operations, can best be executed in a research unit, under the direction and direct supervision of proper specialists. Starting in 1970 at the Cluj-Napoca Institute of Chemistry, scientific research activities were paralleled by organization of production activities, which were subsequently gradually amplified and diversified, so that research work came to be inconceivable to our research workers unless accompanied by production activities on a small or large scale. As a consequence, over the 1975-1984 period the Institute's own production increased eightfold, and the assortment of products increased from 5 to 72. In our opinion, product diversity is even more important than the value of the output created, since it presupposes effective utilization of a larger number of new technologies, although it involves a high volume of labor, not just for manufacture itself, but also for procuring raw materials and for marketing output. In this way conditions are also created for substantial reduction of output in a considerable number of precision synthesis and low-tonnage products.

As is pointed out in the draft directives of the 13th Congress, along with the activities for renovation, modernization, and restructuring of products and manufacturing technologies through promotion of technical and scientific progress, increasing importance and significance are assumed by recovery and re-use of all useful materials resulting constantly from production processes and consumption, this representing an important means for broadening the base of raw and intermediate materials and reducing imports. It is expected that by 1985 a reduction of about 25 percent in consumption of raw materials will be achieved and at least 50 percent of the raw and intermediate materials required will be obtained on the basis of their recovery. Along with the activities for recovery of iron and non-ferrous metals, glass, paper, textile waste, and other waste products, it is necessary to extend this action to all useful elements and substances.

While until recently specialists accepted waste, residues, slag, sludge, etc as a natural effect and an objective factor of the production process,

believing that they could be discarded, there is currently a tendency throughout the world toward complete, 100-percent utilization of raw materials through re-use of all useful components, and toward effort to create products even from the sterile part of a raw material, its "zero-value" component. In this connection we believe that a highly important direction of action is extraction of rare and precious metals from waste in the form of refuse, sludge, slag, dust, and other secondary products resulting from technological processes in which non-ferrous metals are produced. Similarly, vanadium, tungsten, uranium, and many other useful elements can be extracted from slate ash. Precisely for this reason do we believe that there will be need during the forthcoming period for intensive development of research to find and introduce the most efficient solutions for the most efficient possible utilization of various raw and intermediate materials. For example, original, patented technologies have been developed at the Cluj-Napoca Insitute of Chemistry for obtaining high-purity platinum and rhodium from worn catalyst screens. These technologies are applied in production and result in significant reduction of platinum and rhodium imports. At the same time, the Institute is constantly furthering efforts of this kind, technologies being elaborated for utilization of an additional 20 types of recoverable materials containing substantial amounts of palladium, platinum, gold and silver, stainless steel alloys, etc. Some of these technologies are used in the production activities of the Institute, annually yielding appreciable amounts of recovered metals competitive from the viewpoint of purity with imported metals, and others are to be applied at industrial centers of the Chemical Fertilizer Industrial Central Agency in Craiova, the Petroleum Refinery Industrial Central Agency in Brazi, and elsewhere.

Suitable modernization and rapid development of production forces under the conditions of the new technical and scientific revolution, in accordance with the goals established in the draft directives of the 13th Congress, are to be maintained through the most efficient possible scientific and technological development activity. It may be said with full justification that in the years to come science and production will represent two inseparable, and interdependent, aspects of human creative activity. Precisely for this reason must national research, making maximum use of all that is new and of higher quality from the scientific and technical viewpoint, contribute more and more to promotion of technical and scientific progress on the basis of its own intelligence.

The results obtained thus far fully prove the usefulness of combining research with production and education as an efficient means of mobilizing and stimulating original creation, assertion of the innovative spirit. The classification of technical and scientific creation, on the initiative of Comrade Nicolae Ceausescu, as a priority field of socialist competition in the Romanian Song National Festival has resulted and is resulting in imparting a new content and powerful impetus to the scientific and technical creativity of all workers.

Especially in the case of worker centers at which important institutes of higher education are situated, by virtue of the principle of organic linking

of education to research and production, all the activities to which I have referred acquire a new content owing to the possibilities of concentration and accommodation of the entire research potential, material and human, including students, in the direction of conducting interdisciplinary and multidisciplinary activities in critical, pioneer areas, to initiate leading research promoting technical and scientific progress. In reaching this goal of great importance for the policy of our party, the laboratories and industrial production installations of the Cluj-Napoca Institute of Chemistry and other such units in Romania are open at all times to teachers and students, either for organization of on-the-job-training or for carrying out diploma projects under the guidance of experienced research workers. In a considerable number of cases valuable scientific projects have been completed by combined teams made up of research workers and teachers.

In our opinion, certain improvements could be made in the process of intensifying the integration of education with research and production. First of all, the content of the production activities in which young students participate does not always meet the requirements of technical sophistication and educational value. The extent of involvement of students, and sometimes even teachers, in research and development activities, especially on the basis of agreements and contracts, is still insufficient, and the interdisciplinary and teamwork spirit could make itself more strongly felt. To improve the integration process, I believe it to be necessary to draw up plans for optimizing the practical training of young people, carrying out production on the basis of scientific research and development activity linked to the efforts of the university departments, research institutes or groups, and student scientific clubs.

The confidence of the party and its secretary general, Comrade Nicolae Ceausescu, in the strength and capability of Romanian science and technology, the revolutionary orientations imparted to all research, production, and educational activities represent reliable preconditions for carrying out the tasks assigned to us during the forthcoming stage for modernizing the economy and sharply increasing its efficiency, under the conditions of the new technical and scientific revolution.

New Production Forces

Bucharest ERA SOCIALISTA in Romanian No 20, 25 Oct 84 pp 16-18

[Article by Vasile Pilat]

[Text] As has been pointed out by Comrade Nicolae Ceausescu, our era "is the era of the most grandiose scientific and technical revolution known in history."

What we today call a scientific and technical revolution represents a leap forward, a qualitatively new superior moment in scientific knowledge and in technical development embodied in fundamentally new use values. From the viewpoint of the effort to subdue and utilize nature (whereby man secures, facilititates, and enriches his own existence), a decisive role in the

group of use values is played by the consumption or productive use assets, means of production and the knowledge embodied in the quality of the labor force, together with which they form the production forces of society. In essence, the quality of the production forces also determines the efficiency of human productive activity. Consequently, the technical and scientific revolution consists fundamentally in a profound qualitative leap in development of the forces of production.

In our opinion, this leap is manifested in replacement of old production techniques and technologies, that is, old productive capital, with other fundamentally new ones, in transition to a new quality of data processing equipment and behavior of the labor force, and in change in the sector and subsector structure of productive capital and labor force employment. Since techniques, technologies, and information exist as productive forces only while they are in operation, in the production process, qualitative change in productive forces also includes establishment of new performance relationships among different sectors, branches, and subsidiary branches, including economic agencies.

The scientific and technical revolution thus unfolds as a process of profound and manysided qualitative restructuring of the productive apparatus of society, building of a new technical mode of production. The secretary general of our party, Comrade Nicolae Ceausescu, has pointed out that the contemporary technical and scientific revolution "marks a gigantic leap forward in all spheres of knowledge, in development of the forces of production, in growth of the creative capacity of man," and that it "radically modifies the conditions of material production and the possibilities of utilizing natural resources for the benefit of man, and ensures industrial-scale manufacture of wide ranges of new products."

In my opinion, the concept of scientific and technical revolution is not identical to and is not reduced to contemporary discoveries in science, and accordingly not to contemporary technical developments with a potential for revolutionizing engineering and technology. Until they have reached their ultimate form of social and economic development, until the productive forces of society have undergone qualitative change, these technical discoveries and developments of a revolutionary nature have only potential economic value. They do not figure in this process--a decisive instrument in transforming human civilization--which we call the scientific and technical revolution. The history of science and technology in fact offers us many examples of technical discoveries and developments of great revolutionizing potential which were utilized by society only after protracted periods of time had passed or were simply forgotten and later rediscovered or redeveloped.

Scientific discoveries and technical creations with a potential for revolutionizing the forces of production represent only preconditions for the scientific and technical revolution. To convert this potential to reality, to perform their functions of revolutionizing the forces of production, they must pass through the filter of economic exigencies and be integrated into the technical apparatus of production, becoming the ferment or

instrument of qualitative transformation of production. The scientific and technical revolution thus represents precisely the process of economic utilization of fundamentally new scientific discoveries and technical developments, a process whereby they are embodied in forces of production.

Analysis has revealed that passage of productive forces into a qualitatively new stage of their development is not a linear process. It occurs cyclically, in leaps, at long intervals of time (lasting around 50 years). This cycle, of which many explanatory theoretical studies have been made, has been called, depending on one's preference, "macrocycle," "secular cycle," or "Kondratieff cycle." The cyclic process of qualitative change in productive forces is the result of simultaneous action of factors objectively determining, on the one hand, the need for this process (exhaustion of the ability of the productive forces existing at a given time to meet the requirements of efficient economic growth), and on the other the material possibility of occurrence of the respective process. The necessity (which is economic) and the possibility (technical and economic) are the results of the combined and correlated action of three principal factors: the world-level operation of the laws of production and exchange of commodities, the dynamics of scientific knowledge and development based on it, and the dynamics of the relationship of man to nature mediated by the first two factors.

In our opinion, the current process of development of productive forces of a new type (the process which forms the fundamental content of the contemporary scientific and technical revolution) was in effect triggered simultaneously with and by the 1973-1975 world economic crisis. The features characterizing this new type of productive force now being created have been pointed out by many students of the problem, and we will not dwell on them. We will mention only some of the principal changes in the structure of the productive forces which this process entails:

The generation and rapid development of new sectors, in which the most important factor is represented by the results of scientific research are one change. In the current stage they are the sectors forming the basis of the microelectronic revolution: semiconductors (processors and microprocessors), computer equipment, automation elements and systems, robotics, telecommunications systems, data processing systems, etc. These sectors have begun to assume the function of systems "catalyzing" or structuring the system of productive forces and social production. Their output ensures qualitative growth of all other sectors.

The "traditional" sectors are being restructured through qualitative renewal both of their productive apparatus (fixed capital), on the basis of the accomplishments of the new sectors, and of production technologies, on the basis of what is received directly from the sphere of scientific research proper.

The relative importance or ranking of the sectors of social production is undergoing radical change relative to the old system of productive forces; the ranking is determined by the amount and quality of the results received from the sphere of scientific research.

The need for developing new productive forces has arisen worldwide. However, the ability of each national economy to meet this need is determined essentially by internal factors specific to the respective economies. Inasmuch as the level of development of each national economy varies widely, the existence (presence) of the conditions required for conduct of the new stage in the scientific and technical revolution is also extremely varied and differentiated. In our opinion, these conditions are present, in principle, in all the countries which have passed through the stage of basic industrialization, in the course of which a significant scientific-technical and economic potential has been created, as well as a labor force suited for activities of an industrial type. But the degree of presence of these conditions, together with the array of particular features specific to each national economy, of course causes the progress of the scientific and technical revolution itself to assume particular forms differing from one economy to another.

The need for sharp intensification of scientific research and technological development, for full utilization of the latest achievements of the contemporary scientific and technical revolution, represents a major constant in the conception of the secretary general of our party, Comrade Nicolae Ceausescu, of the economic and social development of Romania. At a meeting of the Supreme Council of Economic and Social Development, the leader of our party and state stressed the fact that at the present time "there is being foreshadowed throughout the world a new stage or a new technical and scientific revolution. It will bring about profound changes in the industrial and economic structure of countries and in the development of human society. Consequently, the revolution must be appropriately reflected in the development of Romanian socialist society."

Faithfully reflecting the objective requirements for occurrence of these major transformations in industrial and economic structure, the economic conception and policy promoted by our party and its secretary general are brilliantly expressed in the draft directives of the 13th Congress of the PCR, which, for the sake of continuous modernization of production structures, devotes particular attention to sustained intensification of scientific research and technological development, accelerating the introduction of technical progress, and increase in the role of science and new technologies in all spheres of activity. In this connection, particular attention is paid in the draft directives to development of new sectors and subsectors based on the latest achievements of science, such as electronics (production of electronic components, elements and means of automation, industrial electronic equipment, computer equipment, etc) or precision mechanics, chemistry, etc. As regards the "traditional" sectors, the draft directives stress their modernization and retooling; the investments in these sectors are to be oriented primarily in this direction. On the basis of dynamic development of the sectors producing technical progress, conditions are being created for continuing modernization of the other sectors and vigorous development of other sectors.

One of the chief requirements of the process of continuing development of the national system of productive forces and production, account being

taken of the progress of the scientific and technical revolution and of current trends in world economy, is also reflected in the draft directives in connection with efficient utilization of national natural resources for the purpose of reducing the degree of Romanian dependence on imports of certain mineral raw materials and ensuring energy independence of the country.

Suitable attention is simultaneously devoted to continuing improvement in the organization of economic and social planning and in strengthening worker self-management and economic and financial self-administration. This will also ensure fuller and broader utilization of the enormous potential of our socialist nation for thought and creation, increase in timeliness in conduct of economic life and in the spirit of initiative and responsibility, these being essential requirements for increasing the potential for promoting and giving material expression to the achievements of the scientific and technical revolution.

Extension of Automation

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[Article by Marcel Sirbu, deputy scientific director, Institute of Automation Research and Development]

[Text] The ever wider introduction of automation into nearly all spheres of human activity in effect represents the essence of current technical progress, it being one of the main consequences of the technical and scientific revolution. Mechanization is no longer enough. It was a stage gone through for the purpose of reaching the goals of the first industrial revolution and for making the transition to automation. Under present-day conditions automation is based on continually improving equipment, especially equipment associated with microelectronic components and with data processing programs, and with computers, which, in general, are evolving into "intelligent machines" on the basis of which the preconditions for transition to the second industrial revolution are being created.

Automation is gradually coming to cover the information processes of society as well as production processes. Pronounced cybernetization of production is taking place, along with extension of activities of an industrial type into an increasing number of areas. Industrial robots are used to automate not only continuous technological processes (such as those in chemistry or metallurgy, but ones of a discontinuous nature (such as in machine-building).

At the meeting of the Supreme Council of Economic and Social Development in June 1984, Comrade Nicolae Ceausescu, secretary general of the party, stated that "the plans for the 1986-1990 period are aimed at stressing or accentuating qualitative aspects even more strongly, for intensive development of all activities, more dynamic growth of scientific research work and the role of science and technology in all economic and social development. As is well known, there is being foreshadowed throughout the world a new

stage or a new technical and scientific revolution, which will bring about profound changes in the industrial and economic structure of states, in the development of human society, and thus must be appropriately reflected in the development of Romanian socialist society as well."

To this end, the draft directives of the 13th Congress of the party stress, in all their provisions, the need for sustained promotion in all spheres of advanced science and technology, the latest achievements of human knowledge.

On the basis of increase in the contribution made by scientific research activities and introduction of technical progress in different sectors of the national economy, the forthcoming 5-year plan calls for intensification of the action of the qualitative factors of economic development, as well as substantial increase in the productivity of social labor, whereby about 85 percent of the increase in the national income is to be accomplished. In industry labor productivity will have to increase at an average annual rate of 10 percent, to ensure doubling of productivity in 1990 relative to 1980. The growth of labor productivity will be accomplished chiefly through introduction and dissemination of technical progress, especially through application of new manufacturing technologies, mechanization and automation of production, outfitting with high-output machinery and installations, and modernization of existing equipment.

In point of fact, I consider the most important result of introducing technical progress into production to be represented today by continuing improvement in communication between man and machine, as well as between the various machines which contribute to performance of different production processes. This has been made possible by the appearance of highly developed industrial measurement and control apparatus. Along with improvement in this apparatus, there has been increase in the extent of knowledge of production processes. Generally speaking, communication, man's knowledge, and man's ability to control a machine or a production process represent three essential concepts in automation.

Automation may be defined as the means of replacing, and at the same time of intensifying through the intermediary of machines, the force of human labor (physical and mental) performed to carry out or control production processes and operations. At the same time, automation may also be considered to be a means of improving production. It differs from other forms of technical innovation in that it does not represent a production process per se but leads to improvement and modernization of industrial processes, sometimes even radical transformation of these processes, thereby opening up prospects for the appearance of new processes, with profound implications in many sectors of economic and social life.

While it appeared at the beginning of the first industrial revolution, automation was at that time insignificant as regards its results; because of the low degree of development of technological processes, it was in effect a limited extension of mechanization. But the development of automation at a faster pace and at a high technical level became not only

possible but increasingly necessary, as a result of the development of productive forces to a higher level. This coincided with the beginning of a qualitatively new stage in the development of science and technology, with a revolutionary effect on improvement in production processes.

I believe it to be quite right to state that in recent decades the evolution of automation has been characterized chiefly by the introduction of computers in control of production processes. They permit not only monitoring of execution of production processes, but continuous optimization of these processes as well. "Industrial data processing" has thus made its appearance and is now becoming ever broader in scope, being in effect a new mode of automation, "programmed automation," also termed "flexible automation."

It may be estimated that during the forthcoming period, as a result of introduction of electronics and computers, microprocessors, on an ever larger scale, automation will permit control of the most complex technological processes under conditions of incomparably higher efficiency. Moreover, the problem of complete re-examination of many production processes, of conducting these processes at a truly revolutionary level of quality and accuracy, without the intervention or direct participation of man, is asserting itself with increasing insistence.

Barely half a century has passed between the appearance of the first automated machinery and equipment and attainment of the stage of control of large industrial complexes and centers by means of hierarchically ranked and distributed management systems using minicomputers and microcomputers, but the entire history of the explosive development of the applications of automation in production of material goods in effect falls in this relatively brief period. It may be quite confidently stated that automation will penetrate into practically all the spheres of productive activity, gradually taking over an entire spectrum of activities of directly productive and auxiliary personnel and of administrative, research and development, and even management personnel. An ever greater number of completely automated enterprises will make their appearance, and only a few supervisory personnel will be employed in them. While the initial effects of automation led to freeing of man from performance of heavy physical labor, in the future automation will include an increasing number and greater variety of mental activities, thereby opening up new prospects for dynamic increase in labor productivity in all sectors of economic and social activities.

The increasing complexity of technological processes is today leading to gradual growth of the share of automation equipment in the value of investments for new industrial facilities. The ratio of the value of investment in automation equipment to the total investment value of a particular industrial facility expresses the degree of automation, as well as the degree of modernization of production processes. In Romania the level of automation has risen dramatically over the last two decades as a result of consistent application of the concept of Comrade Nicolae Ceausescu, secretary general of the party, regarding the basing of all economic and social development on the latest achievements of science and technology. In certain

advanced sectors of the national economy (chemistry, power engineering, machine-building), the level of automation is today near that of the advanced countries (8-12 percent).

Another indicator of automation is represented by the percentage of industrial production created in automated and mechanized systems. According to the provisions of the draft directives of the 13th Congress of the party, the percentage of industrial production completed in these systems is to be 70 percent by 1977 and more than 90 percent by 1990.

The extension of automation and computerized control of large industrial complexes creates especially important problems for scientific research and technological engineering in the sphere of automation. Thus, I believe that, above all, the overall efficiency of introducing automation equipment and systems should be reflected in dramatic increase in labor productivity, and at the same time in increasingly rational utilization of energy and fuel resources and raw and other materials with higher efficiency. Generally speaking, the main economic effects obtained as a result of automation are reflected in the additional capital accumulation effected by the economy as a whole through increase in the volume of production as a result of elevation of the level of productivity of automated equipment and installations (reduction of the time of interruption of production processes, optimization of these processes, use of new manufacturing technologies and computerized control); lowering of the cost price of production as a result of reduction of the specific consumption of raw and other materials, lower consumption of fuels and electric energy, as well as reduction of expenses for maintenance of equipment and investments and reduction of the amount of labor per unit product; and improvement in product quality and reduction of rejects.

I believe that during the forthcoming period the introduction of microprocessors for control of production processes will represent the principal trend in the evolution of means of automation, along with transition to a new stage in the technical and scientific revolution. This will bring about substantial increase in the dependability of operation of automation equipment, along with rapid development of electronic components characterized by a high and very high degree of integration. There will be extensive diversification of the types of automation equipment based on use of microprocessors, and the use of numerical control units and distributed control systems will be extended and become widespread, numerical control systems being incorporated even into the structure of machines. The use of systems for remote control of technological processes will be increasingly extended, with a tendency toward optimization of systems on the basis of the principle of achieving maximum product quality with minimum consumption of material resources and energy.

As is stated in the draft directives of the 13th Congress, in Romania a transition will be made to large-scale production of completely automated and robotized production lines, sections, and sectors during the forthcoming five-year plan. Action will also be taken to speed up introduction and extension of the automation of production processes in foundries and forges, in the chemical industry, machine-building, transportation, etc. To this

end, scientific research and technological engineering must proceed to create modern automation equipment produced chiefly with extensively integrated electronic components; elaborate advanced generations of distributed management and control systems based on the use of microprocessors; design automation systems for specialized uses in mining, extraction and distribution of petroleum and gas, agriculture, nuclear power engineering, transportation, etc, by use of standardized modules; develop machine-tools, industrial robots, and flexible technological assemblies and lines based on standardized modules with microprocessors; and design new types of controllable drives, static converters with applications in metallurgy, machine-building, power engineering, etc, as well as automatic testing equipment and specific equipment for mechanized and automated mounting and assembly of various products.

I am fully convinced that the great scientific, technical, and human potential available to us today and the wide experience gained in creation and introduction of automation equipment and systems represents a guarantee of new and important achievements in this sphere during the forthcoming five-year plan and beyond, with profound implications in dramatic accentuation of the qualitative aspects of economic and social activities, on the basis of introduction of the latest achievements of the technical and scientific revolution.

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